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NATIONAL DAM SAFETY PROGRAM. DORLAC LAKE DAM (MO 30731). MISSIS--ETC(U)
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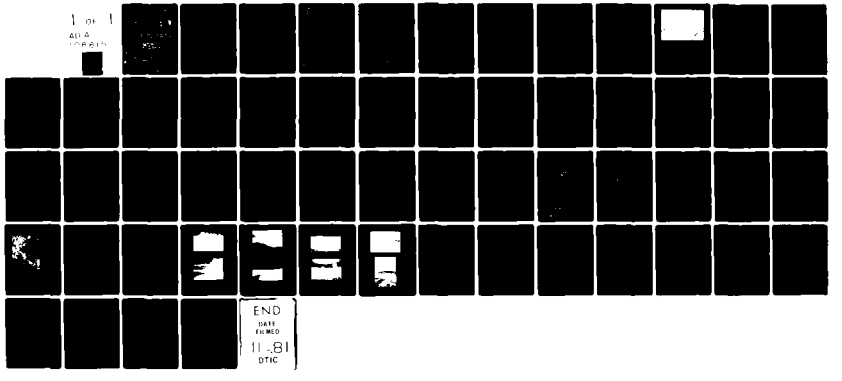

LEVEL II

MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

DORLAC LAKE DAM
WASHINGTON COUNTY, MISSOURI
MO 30731

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
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St. Louis District

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

OCTOBER 1980

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Dorlac Lake Dam (MO 30731) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Dorlac Lake Dam (MO 30731). It was prepared under the National Program of Inspection of Non-Federal Dams. Dorlac Lake Dam is an aritificial man-made barrier that retains mine tailings. The present condition of the tailings is unknown. Further investigations would be required to determine the true condition of the material contained within the tailings pond. These investigations are beyond the scope of a Phase I investigation and are the responsibility of the State or owner.

SUBMITTED BY: SIGNED — 16 APR 1981

Chief, Engineering Division — Date

APPROVED BY: SIG — 20 APR 1981

Colonel, CE, District Engineer — Date

DORLAC LAKE DAM

Washington County, Missouri

Missouri Inventory No. 30731

Phase I Inspection Report

National Dam Safety Program.

(6)

Dorlac Lake Dam (MO 30731).
Mississippi - Kaskaskia - St. Louis Basin.
Washington County, Missouri. Phase I
Inspection Report.

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

(9) Final rept.,

(15) DACW43-80-C-0066

(10) Richard G. /Berggreen
Leonard M. /Krazynski

Under Direction of

St Louis District, Corps of Engineers

(12) 51

for

Governor of Missouri

(11) Apr[redacted]81

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Dorlac Lake Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of Mineral Fork
Date of Inspection	16 August and 2 October 1980

Dorlac Lake Dam, Missouri Inventory Number 30731, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), and Sean Tseng (hydrologist). The dam is an abandoned barite tailings dam.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide for an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited scope of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District (SLD), Corps of Engineers, has classified this dam as having a high hazard potential. The estimated damage zone length extends approximately 2 mi downstream of the dam. Approximately seven homes and Missouri Highway 21 are located within this damage zone.

The dam is classified intermediate size based on its height of about 45 to 50 feet. The storage capacity is approximately 760 ac-ft (this storage volume is currently filled with tailings). An intermediate size dam is between 40 and 100 ft in height or 1000 and 50,000 ac-ft in storage capacity.

Our visual inspection and analysis of available data indicate the dam is in generally fair to good condition. No evidence of unstable slopes, disruption of the vertical or

horizontal alignment, excessive settlement, animal burrows, cracking or serious erosion was noted.

The downstream face is steep, on the order of 33 to 35 degrees, is constructed of cohesionless sand and gravel, and could be severely eroded if overtopped. Scattered large trees up to 12 in. diameter are growing on the downstream face of the dam.

The reservoir storage volume is completely filled with fine tailings and storage of water is limited to two small ponds at the upstream end of the impoundment, and shallow, intermittent ponds on the surface of the tailings.

Hydraulic/hydrologic analyses indicate the dam and informal spillway will pass the 1 percent probability-of-occurrence event (100-year flood) without overtopping the embankment. These analyses further indicate the dam will be overtopped by a storm which produces greater than 55 percent of the Probable Maximum Flood (PMF). The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Based on our inspection of Dorlac Lake Dam, it is recommended that further study be conducted without undue delay, under the guidance of an engineer experienced in the design and construction of tailings dams, to include, as a minimum:

1. Design and construction of a spillway and discharge channel of adequate capacity to pass the PMF storm without overtopping the embankment, as required by the Guidelines. Location and capacity of the discharge channel should be such as to inhibit potential erosion at the toe of embankment, and flooding of the residences immediately below the spillway.

2. Evaluate establishment of an effective, practical warning system for advising downstream residents should unsafe conditions develop at the facility.

3. Perform static and seismic stability analyses and seepage analyses as per the recommended guidelines.

4. Evaluate the need to remove large trees from the downstream face of the embankment. Removal of large trees should be performed under the guidance of an engineer experienced in design and and construction of earth dams. Indiscriminate clearing of large trees could jeopardize the safety of the dam.

5. Deactivation of Impoundment. As an alternative to the above remedial measures, a plan to permanently drain the impoundment and reclaim the embankment and tailings pond could be developed. Such a plan should make provisions for the safe removal of storm runoff and for maintaining the stability of the dam and impounded tailings at all times. Preparation and implementation of such a reclamation plan should be accomplished under the direction of an engineer experienced in the design and construction of tailings dams.

6. It may be possible to change the length of the estimated damage zone by performing an in-depth study of the consistency of the tailings in the reservoir area, in order to determine the extent to which they may flow in the event of a dam failure.

7. A program of periodic inspections should be initiated to identify evidence of slope instability and increases in the amount of seepage flow or turbidity of the seepage water. Reports of inspections and any recommended maintenance should be made a matter of record.

It is suggested that the owner take action on these recommendations without undue delay to avoid deterioration of this structure which could lead to the development of unsafe conditions.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen,
Registered Geologist

Leonard M. Krazynski, P.E.
Vice President

OVERVIEW
DORLAC LAKE DAM

MISSOURI INVENTORY NUMBER 30731

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DORLAC LAKE DAM - MISSOURI INVENTORY NO. 30731
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DORLAC LAKE DAM, MISSOURI INVENTORY NO. 30731

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of Dorlac Lake Dam, Missouri Inventory Number 30731.

b. **Purpose of inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams," and Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams," prepared by the Office of Chief of Engineers, Department of the Army; and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams," prepared by the St Louis District (SLD), Corps of Engineers. These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenant structures.** Dorlac Lake Dam is an abandoned tailings dam. Its construction procedure and usage are typical of other barite tailings dam in the area but are not typical of dams constructed for the impoundment of water. The unique nature of these tailings dams has a significant impact on their evaluation. A brief description of the general construction procedure and usage of Missouri barite tailings dams is necessary to understand the unique nature of these dams, and understand the differences between these dams and conventional water-retaining dams.

At the start of a barite mining operation in this area, a 10 to 20-ft high starter dam is usually constructed across a natural stream channel. Generally the streams are intermittent so that construction is carried out in the dry. Trees and other vegetation are removed from the dam site, and a cutoff trench is often made to shallow bedrock. Locally obtained earth, usually a gravelly clay, is then placed to form the embankment. Compaction is generally limited to that provided by the equipment.

The barite ore is contained within the residual gravelly clay which is mined with earth-moving equipment. At the processing plant, the ore is washed to loosen and remove the soil. This water is obtained from the reservoir area behind the dam. The soil-laden wash water and water from other steps in the process is then discharged into the reservoir. There, the soil is deposited by sedimentation and the water recycled. Another step in the process removes the broken gravel-sized waste which is called "chat."

As the level of the fine tailings increases, the dam is raised. The usual method is to dump chat on the dam crest. The chat is spread over the crest so that a relatively constant crest width is maintained as the dam is raised. Generally the crest centerline location is also maintained. However, the crest centerline location may migrate upstream if there is insufficient chat available, and downstream if an excessive quantity of chat is available. The latter is uncommon, because it is indicative of a poor ore deposit.

This method of construction results in embankment slopes which are close to the natural angle of repose for the chat. They can be considered to be near a state of incipient failure.

A large quantity of water is required for barite processing, on the order of 2000 to 5000 gal/min. Thus, it has been the operators' practice to construct the dam so that all inflow to the reservoir is recycled in order to have sufficient water for the operation. The result is that formal spillways or regulating outlets are generally not constructed. In most cases, a low point on or near the dam is provided for overflow, should the storage capacity be exceeded.

The fine tailings typically fill more than 80 percent of the total storage volume. This results from the operator's practice of maintaining only a 2 to 5 ft elevation differential between the level of the tailings and the dam crest. The differential is usually greater further away from the discharge point and also typically further away from the dam.

The geotechnical characteristics of the fine tailings are somewhat similar to recent lacustrine clay deposits. Where the tailings have been continuously submerged, they have a very soft consistency and high water contents. When evaporation causes the water level to recede and the tailings are exposed, a stiff crust forms as the tailings dry out. Below the crust, the tailings retain their soft consistency for long periods of time. This consistency is very gradually modified by a slow process of consolidation.

Dorlac Lake Dam is generally typical of barite tailings dams in this area. There is no formal spillway; overflow occurs at the right (north) abutment where the embankment has apparently been lowered to allow overflow. There are no control structures to regulate outflow in this area. This low area is crossed by a gravel road which runs along the crest of the dam.

The tailings impoundment is full. The tailings surface is at the elevation of the embankment crest. No significant water storage can apparently occur on the tailings surface. Two small ponds are impounded, at the upstream end of the tailings area, by a gravel road which crosses the tailings surface. The

surface of the tailings is desiccated, forming a stiff upper crust. The surface is intermittently mowed with mechanized equipment.

Two small to moderate size ponds are located immediately downstream of the tailings dam. The upper pond at the immediate toe of the tailings dam is impounded by an 18 ft dam, and may cover 10 to 15 feet of the toe of the tailings dam. The total height of the tailings embankment is therefore estimated at 45 to 50 ft. Immediately below this pond is a second larger pond, also with a dam approximately 18 ft in height. Discharge from the Dorlac Lake reservoir area will flow into the upper pond, then the lower pond, before entering the stream bed which flows north to Mineral Fork. The ponds appear to be spring fed as both had small flows through their spillways at the time of our field inspection, after an extended dry period. No runoff was occurring at that time from the Dorlac impoundment. An estimated 1 to 2 gal/min was flowing from the upper pond, and an estimated 5-6 gal/min was flowing from the lower pond at the time of the field inspection.

b. **Location.** The dam is located on an unnamed tributary of Mineral Fork, about 1 mi downstream from the community of Cannon Mines, and about 1 mi southwest of Washington State Park (Fig. 1). The dam is shown on the advance print of the USGS Tiff, Missouri 7.5 minute quadrangle sheet (Fig. 2) Section 33, T39N, R3E.

c. **Size classification.** The dam is classified as intermediate size based on the approximate 45 to 50 ft height of the dam. The storage volume is approximately 760 ac-ft. This storage is filled entirely with fine tailings. The intermediate dam classification includes dams of 40 to 100 ft in height, or having a storage volume of 1000 to 50,000 ac-ft.

d. **Hazard classification.** The St Louis District (SLD), Corps of Engineers, has classified this dam as having a high hazard potential. The SLD estimated damage zone length extends approximately 2 mi downstream. Approximately 7 dwellings and Missouri State Highway 21 are located in the first mile of this estimated damage zone. The loss of life and property could be significant if the dam failed and if the impounded tailings were subject to flow during the periods of heavy rainfall.

e. **Ownership.** We understand the dam is owned by Mr John Dorlac, Route 1, Cadet, Missouri, 63630.

f. **Purpose of dam.** The dam was constructed to impound fine barite tailings mined in the vicinity. Water was recycled from the reservoir and used in the barite processing operations. The dam is currently abandoned.

g. **Design and construction history.** No records were found for the design or construction of this dam. The field inspection indicated the dam was constructed according to standard procedures for tailings dams in the area as outlined in Section 1.2a. The downstream slope of this dam has been constructed in a more irregular shape than is usual for other similar tailings dams in this area.

Mr Dorlac, the present owner, indicated the dam was constructed in about 1940 or 1941 by the old Desoto Mining Company, but no records of design or construction were available. Mr Dorlac was contacted during the inspection visit, but did not accompany the team during the inspection.

h. **Normal operating procedures.** No facilities requiring operation are present at this facility. No records of past operations were found. Mr Dorlac indicated the tailings impoundment is sufficiently firm to support a D-7 bulldozer used to remove trees from the tailings surface. The tailings surface is periodically mowed to remove willow-type vegetation.

1.3 Pertinent Data

a. **Drainage area.** 0.48 mi^2

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	Not Applicable (N/A)
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A

Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	1642 ft^3/sec (at elev. 750.0)
Total spillway capacity at maximum pool elevation	1642 ft^3/sec (at elev. 750.0)

c. **Elevation (ft above MSL).** (Note: Elevations surveyed were not carried from known benchmark elevation. MSL datum correlation made from topographic map. Elevations may be ±5 ft with respect to MSL, but the relative elevations are within limits of survey error).

Top of dam	750.0 to 754.7
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater - (pond at the toe)	712
Toe of dam at maximum section	700 (estimated, covered by water)

d. **Reservoir.**

Length of maximum pool	2450 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	760 (This volume filled with fine tailings)

f. **Reservoir surface (acres).**

Top of dam	34
Maximum pool	34
Flood control pool	N/A
Recreation pool	N/A
Spillway crest	32

g. **Dam.**

Type	Barite tailings
Length	600 ft
Height	Approx. 45 to 50 ft (38 ft exposed above water level of pond at toe of dam)
Top width	30 ft
Side slopes	Upstream unknown
	Downstream 1.5(H) to 1(V)
Zoning	Unknown (probably none)
Impervious core	Unknown (probably none)
Cutoff	Unknown (probably shallow trench)
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

Type	Broad, earth-lined, roughly trapezoidal notch cut at right (north) abutment.

Length of weir	300 ft at el 750 (minimum top of dam)
Crest elevation	747.4 ft
Gates	None
Downstream channel	No distinct downstream channel. Overflow will flow along roadway and down natural hillside to lower ponds. May be a hazard to homes downstream during heavy flows.

j. **Regulating outlets.** None

SECTION 2
ENGINEERING DATA

2.1 Design

No design data or other engineering data are known to exist.

2.2 Construction

No construction records are known to exist. Construction is apparently typical of barite dams in the area. See Section 1.2a. Downstream slope is more irregular than is usual for similar dams.

2.3 Operation

No operation records are known to exist.

2.4 Evaluation

a. **Availability.** No engineering data were available for review.

b. **Adequacy.** The available data are insufficient to evaluate the design of Dorlac Lake Dam.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of tailings dams.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site lies on the northern flank of the Ozark structural dome. The regional dip is to the north. The bedrock in the area is mapped as Cambrian age Eminence and Potosi dolomite formations on the Geologic Map of Missouri (Fig. 4). The Potosi Formation is a medium- to fine-grained, light gray dolomite, and typically contains an abundance of quartz druse characteristic of chert-bearing formations. The Eminence Formation conformably overlies the Potosi Formation, and is similar in appearance but contains less quartz and chert. Both formations are mined for barite ore. Some caves and large springs have been found in the Eminence Formation in parts of Missouri, but were not observed in the vicinity of Dorlac Lake Dam during our inspection.

The owner Mr Dorlac, indicated the lower two ponds were spring-fed. The clarity of the water and seepage adjacent to the upper pond supports this information. No evidence of sinkhole development or other karst features in the vicinity of the dam were noted during the field inspection.

The soil at the dam site is a dark red-brown, plastic residual clay (CH), characteristically developed on the Potosi Formation. It is locally overlain by 1 to 5 ft of silty loess (ML). The area is mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Cruise Mill-Fertile Fault Zone lies approximately 1 mi north of the dam site and is mapped on the Structural Features Map of Missouri (1971) as discontinuous for approximately 19 mi (including the Richwoods Fault Zone), trending WNW-ESE. The fault zone is mapped as north side up. This fault is likely Paleozoic in age, is not in a seismically active area, and is not considered to pose a significant earthquake hazard.

The dam is located approximately 125 mi northwest of the line of epicenters for the very large New Madrid earthquakes which occurred in 1811 and 1812. A recurrence of an earthquake of the magnitude of the New Madrid events could cause damage to the dam, but an assessment of this risk is beyond the scope of this Phase I investigation.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** Dorlac Lake Dam was inspected on August 16, 1980 at a reconnaissance level, and on October 2, 1980 for a field survey and additional visual inspection. These inspections indicated the dam was in generally fair to good condition.

b. **Dam.** The dam is constructed of coarse barite tailings, called chat, generally less than 3/4 in diameter, but locally containing cobbles to 4 in. The material is predominantly sandy gravel and sand (GW-SW), appears cohesionless and permeable, and would likely be severely eroded if the dam were significantly overtopped (Photos 1 and 8).

The downstream face of the dam has a slope angle of approximately 33 to 35 degrees, i.e. 1.5(H) to 1(V), which appears to be near the natural angle of repose for this material (Photos 2 and 8). The slopes are judged to be near a state of incipient failure.

No evidence of horizontal or vertical disruption of the dam crest alignment was noted. The noticeably irregular shape at the center of the downstream face of the dam (see Overview Photo and Photo 2) appears to be a product of construction practices rather than slope instability.

No evidence of serious erosion, excessive settlement, cracking, animal burrows, depressions or sinkhole development was noted during the field inspection.

Seepage was noted along the natural hillside below the left abutment of the dam (Fig A-1, Appendix A). A broad area, perhaps 50 ft wide, was seeping into the upper pond. Total seepage was estimated at 1 to 2 gal/min. No soil was noted in the seepage water. This seepage may have been from a natural spring or seepage area, as no surface water was present in the impoundment above this seepage area.

The center section of the toe of the dam is under water, covered by the upper of two ponds immediately downstream of Dorlac Lake Dam (Photos 2 and 7). It is estimated that this pond may cover the bottom 10 to 15 ft of the downstream face of Dorlac Lake Dam.

Vegetation on the downstream face consists of scattered trees, as large as 12 in. in diameter, and bushy vegetation (Photos 1 and 2).

c. **Appurtenant structures.**

Spillway. There is no formal spillway at this dam. The embankment is lower at the north end to allow runoff to flow into the downstream ponds. A gravel road crosses this informal spillway area and traffic or maintenance of the road has removed any evidence of prior erosion in this area (Photo 4).

d. **Reservoir area.** The reservoir area was almost completely filled with fine tailings to the level of the top of the dam (Photos 3 and 5). The surface of the tailings was densely vegetated with willow-type vegetation at the time of the reconnaissance visit, but had been mowed to about 3 in. height by the second site visit.

Storage of water will apparently be limited to two shallow ponds at the upstream end of the tailings impoundment (see Overview Photo). A small amount of water may also be stored in shallow depressions on the surface of the impoundment but will apparently be limited to only a few acre-feet at most.

The slope of the surface of the tailings appears to be such that runoff will be directed to the informal spillway area.

Slopes surrounding the reservoir area are quite flat, on the order of 10(H) to 1(V) or flatter. No evidence of unstable slopes was noted during the visual inspection.

e. **Downstream channel.** The downstream discharge channel for Dorlac Lake Dam is indistinct, consisting of a broad low area below the informal spillway. Storm flow would apparently flow along a gravel road below the spillway (Photo 4) and could flow into the pond at the toe of the tailings embankment and/or (during the periods of heavy flows) toward the Dorlac residence (Photo 6) located along the gravel road (Fig. A-1, Appendix A). More detailed surveying and inundation studies would be necessary to determine the potential flooding of the residence resulting from heavy storm flows through the informal spillway. No record or visual evidence of any past flooding was reported or observed during our field inspection.

3.2 Evaluation

Our visual inspection indicates the dam is in generally fair to good condition. The downstream face is very steep, approximately 1.5(H) to 1(V), and consists of erodible sandy gravel and sand (GW-SW). Vegetation on the dam consists of scattered trees and brush on the downstream face. The upstream face is completely covered by fine tailings.

No evidence of displacement of the vertical or horizontal alignment of the dam, or of excessive settlement, cracking, erosion, animal burrows, or sinkhole development was noted. The irregular configuration of the downstream face appears to be the result of construction techniques rather than unstable slopes.

The tailings surface is essentially level with the top of the embankment. Storage is almost entirely taken up by the fine tailings. Two small upstream ponds and very shallow intermittent ponds on the surface of the tailings comprise the only available water storage.

The spillway is a broad low area at the right abutment. It is unlined and crossed by a gravel road. The broad downstream discharge channel flows into the ponds at the toe of the tailings embankment and past the Dorlac residence. No evaluation was made of any possible flood potential to the residence during significant flood events.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No operating procedures currently exist as the dam has been abandoned.

4.2 Maintenance of Dam

Maintenance appears limited to periodically mowing vegetation on the surface of the impoundment and maintaining the gravel road on the dam crest.

4.3 Maintenance of Operating Facilities

Not applicable.

4.4 Description of Any Warning System in Effect

The visual inspection did not identify any warning system in effect at this dam.

4.5 Evaluation

The continual use of the gravel road on the dam crest suggests maintenance of this road will continue. The proximity of the owner's house to the dam further indicates that any deterioration due to erosion would likely be noticed and repaired. An evaluation of the need to remove large trees from the downstream face of the dam is recommended. Removal of large trees should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing of large trees could jeopardize the safety of the dam.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design information was available for evaluation of this reservoir and dam. Pertinent dimensions of the dam and reservoir were surveyed on 2 October 1980, measured during the visual inspection or estimated from USGS topographic maps. The map used in the analysis is the advance print of the USGS Tiff Missouri 7.5 minute quadrangle map. It should be noted that the surveyed elevations of the dam crest and spillway sections were not surveyed from a known benchmark. The surveyed Datum was correlated with Mean Sea Level Datum using the USGS topographic map. As a result, elevations could be $\pm$ 5 ft from true MSL elevations, but the relative elevations are within the limits of survey error.

b. **Experience data.** No recorded history of rainfall, runoff, discharge, or pool stage data was available for this reservoir and dam.

c. **Visual observations.** Dorlac Lake Dam is an abandoned tailings dam. No formal spillway was identified during the visual inspection. The informal spillway located at the right abutment is a broad low area which is unlined and could be subject to some erosion during significant flood events. Other observations regarding the reservoir, dam, or spillway are presented in Section 3, Visual Inspection.

Seepage noted during the visual inspection is not hydrologically significant in the overtopping analysis.

d. **Overtopping potential.** The overtopping potential hydrologic analysis for this dam was performed using the "HEC-1, Dam Safety Version" (1 April 1980) computer program. The method used, the data and output summaries are presented in Appendix B. Since the dam is made of erodible materials positioned on very steep slopes, overtopping could result in substantial erosion of the embankment. Substantial erosion could in turn lead to failure of the dam. It is not possible to make a reasonable prediction of the distance

that the impounded tailings would flow, or of the amount of tailings that would be released, if the dam were to fail, without an in-depth study of the consistency of the tailings. If a major movement of the tailings did occur, the safety of the downstream residences could be threatened. Water displaced from the downstream ponds by an inflow of tailings, subsequent to a failure, would increase the hazard. The analyses show that the dam would be overtopped by any hydrologic event greater than 55 percent of the Probable Maximum Flood (PMF). The PMF is defined as the flood event which may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The 1 percent probability-of-occurrence event (100-year flood) would be passed by the informal spillway without overtopping the dam.

The following results were obtained for the dam from the hydrologic/hydraulic analyses summarized in Appendix B:

Precipitation Event	Max Reservoir W.S. Elev., ft (MSL)	Max Depth of Overtopping, ft	Max Outflow, ft^3/sec	Duration of Overtopping, hrs
50% PMF	749.8	0	1400	0
55% PMF	749.9	0	1542	0
60% PMF	750.0	0.01	1642	0.3
100% PMF	750.5	0.52	2570	2.0

It should be noted that the choice of elevation 750.0 as the critical elevation for the overtopping analyses was made based solely on our assessment of the erosion and safety hazard to the main body of the dam. No assessment was made of any flooding potential to the downstream residences which may result from the heavy spillway flows, as the downstream discharge channel area is irregular and not well defined.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** Several features which could affect the structural stability of the dam were identified during the visual inspection. These include:

1. The steep downstream face of the dam, measured at 33 to 35 degrees, near the natural angle of repose for this material;

2. The erodible nature of the embankment materials in the event of overtopping by water;

3. The toe of the embankment being under water. Rapid drawdown of the pond at the toe could pose a hazard to the embankment stability;

4. Vegetation on the dam (potential effects of uprooting or decay of large trees and root systems).

b. **Design and construction data.** No design or construction data relating to the structural stability of the dam were found. In particular, seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. **Operating records.** No appurtenant structures requiring operation exist at this dam.

d. **Post construction changes.** The lack of design and construction drawings and records precludes reliable identification of post construction changes. However, two changes appeared apparent from the visual inspection.

The dam crest appears to have been slightly lowered by removal of some of the chat, probably for road building or maintenance in the area. It appears that the present configuration would have resulted in shallow constant overflow of processing water during barite milling operations. This lowering of the crest, if any, has not adversely affected the structural stability of the embankment.

The second post construction change noted was the construction of the two ponds immediately downstream of the dam (Photo 7). This has caused water to be impounded against the toe of the tailings dam (Photo 8). A rapid drawdown of water in the upper pond could cause seepage pressures to develop at the base of the tailings dam and result in slides or failure of this embankment.

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Since no static stability analysis is available for review, the seismic stability cannot be evaluated. However, as the tailings are fine-grained, saturated materials and the dam is made of loose, granular material, substantial deformation damage or failure could occur during a severe seismic event.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, Dorlac Lake Dam embankment appears to be in a generally fair to good condition. Seepage and stability analyses as required by the "Recommended Guidelines for Safety Inspections of Dams" are not on record, which is considered a deficiency.

As a consequence of the widely-used procedure for construction of barite tailings dams, the slopes of the dams are placed at the angle of natural repose for the material. This results in slopes which are very steep and exist near incipient failure with safety factors approximately equal to one. Gradual improvement of the factor of safety against overall slope failure can be expected with time, as consolidation and desiccation of the impounded fine-grained tailings increase their strength and decrease the lateral driving forces acting on the embankment.

The slopes placed at the angle of natural repose will only remain stable if they are protected against changes that will increase load or decrease strength. Such changes include but may not be limited to the following:

1. Overtopping by water.

2. Higher pore pressures (or seepage forces).

3. Undercutting of the toe of the slope by erosion.

4. Increase in the height of the slope.

5. Liquefaction (such as may result from a seismic event).

The first four changes are subject to partial control by owners and must receive careful attention to maintain stable dam embankments. The fifth influence represents a risk, the magnitude of which cannot be estimated without further study.

b. **Adequacy of information.** Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available; this precludes an evaluation of the structural and seismic stability of the dam. The lack of these analyses is considered a deficiency.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Corrective actions should be initiated without undue delay.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspections of Dams", the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed without undue delay are described in Section 7.2.b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options available which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of the dam and/or construct a spillway adequate to pass the Probable Maximum Flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Provide a highly reliable flood warning system (generally does not prevent damage but decreases chances of loss of life).

b. **Recommendations.** Based on our inspection of Dorlac Lake Dam, it is recommended that further study be conducted without undue delay, under the guidance of an engineer experienced in the design and construction of dams, to include, as a minimum:

1. Design and construction of a spillway and discharge channel of adequate capacity to pass the PMF storm without overtopping the embankment, as required by the guidelines. Location and capacity of the discharge channel should be such as to inhibit potential erosion at the toe of embankment, or flooding of the residences immediately below the spillway.

2. Evaluate establishment of an effective, practical warning system for advising downstream residents should unsafe conditions develop at the facility.

3. Perform static and seismic stability analyses and seepage analyses as per the recommended guidelines.

4. Evaluate the need to remove large trees from the downstream face of the embankment. Removal of large trees should be performed under the guidance of an engineer experienced in the design and construction of earth dams. Indiscriminate clearing of large trees could jeopardize the safety of the dam.

5. Deactivation of Impoundment. As an alternative to the above remedial measures, a plan to permanently drain the impoundment and reclaim the embankment and tailings pond could be developed. Such a plan should make provisions for the safe removal of storm runoff and for maintaining the stability of the dam and impounded tailings at all times. Preparation and implementation of such a reclamation plan should be accomplished under the direction of an engineer experienced in the design and construction of tailings dams.

6. It may be possible to change the length of the estimated damage zone by performing an in-depth study of the consistency of the tailings in the reservoir area, in order to determine the extent to which they may flow in the event of a dam failure.

c. **O & M procedures.** A program of periodic inspections should be initiated to identify evidence of slope instability and increases in the amount of seepage flow or turbidity of the seepage water. Reports of inspections and any recommended maintenance should be made a matter of record.

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Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, scale 1:500,000.

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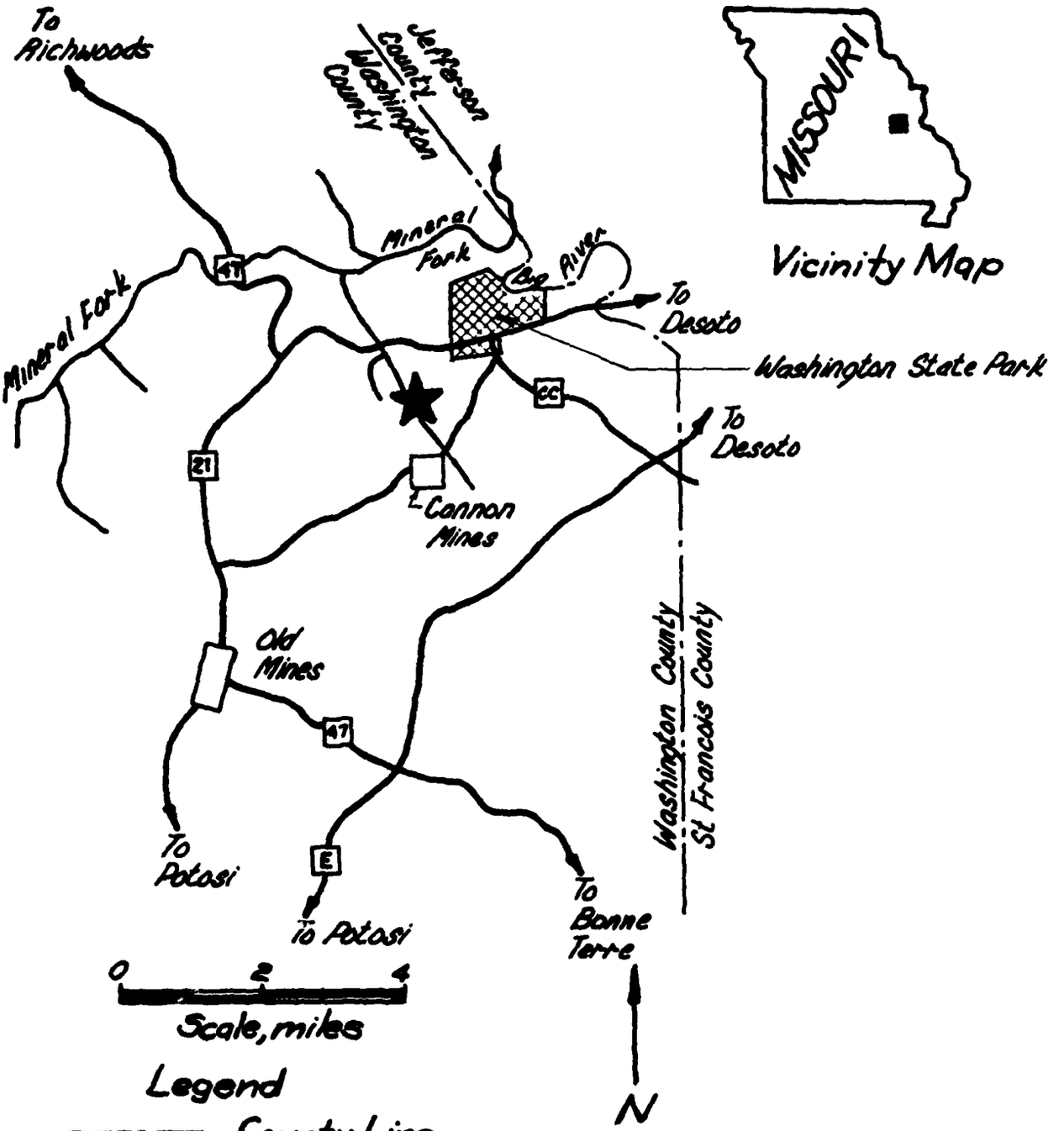
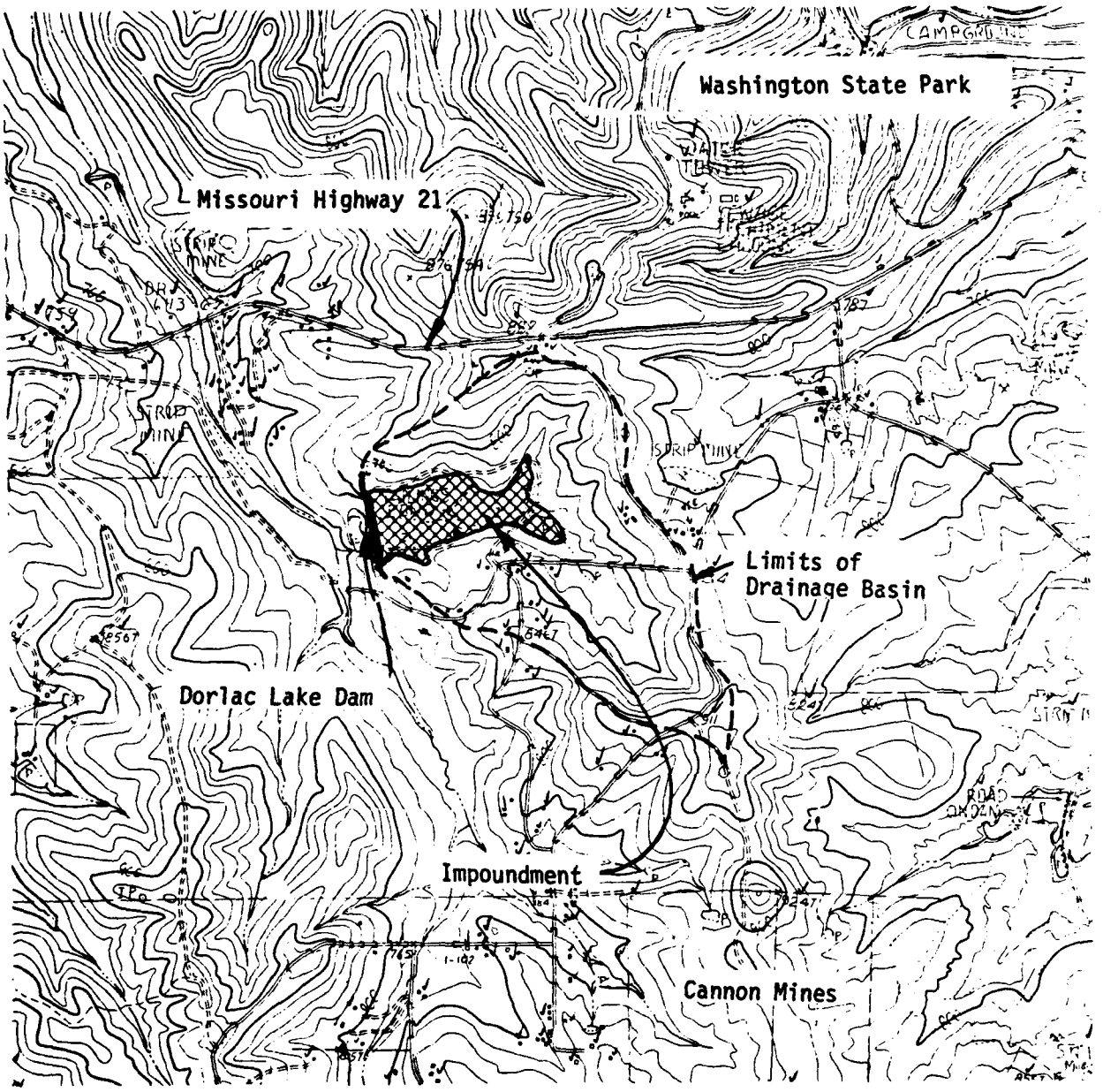
US Department of Commerce, US Weather Bureau, 1956, Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours, Hydrometeorological Report No. 33.



SITE LOCATION MAP	
DORLAC LAKE DAM	
MO 30731	Fig. 1

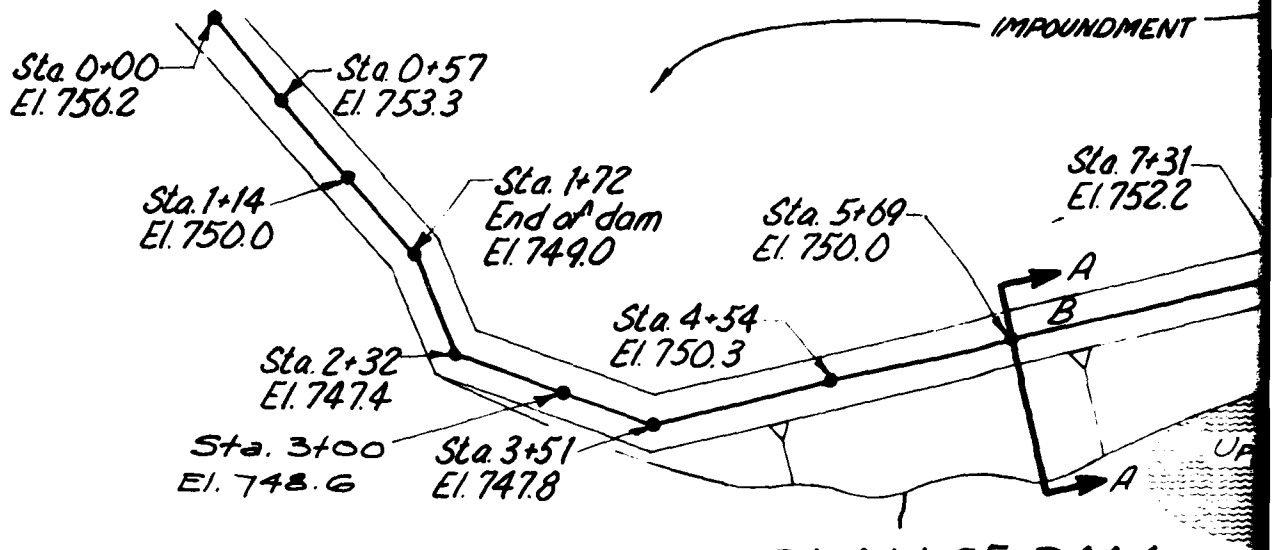


Notes

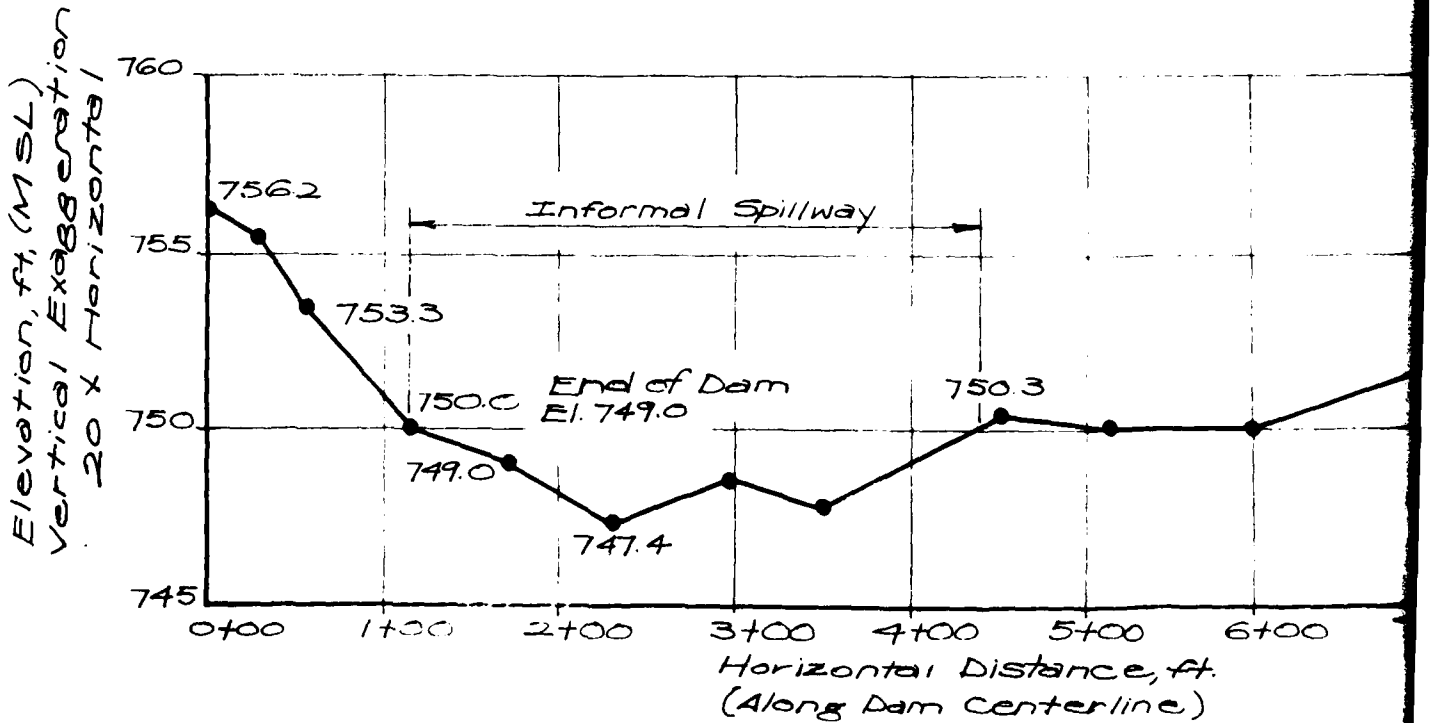
1. Topography from advance print USGS Tiff, Missouri 7.5 quadrangle map.

DRAINAGE BASIN AND SITE TOPOGRAPHY

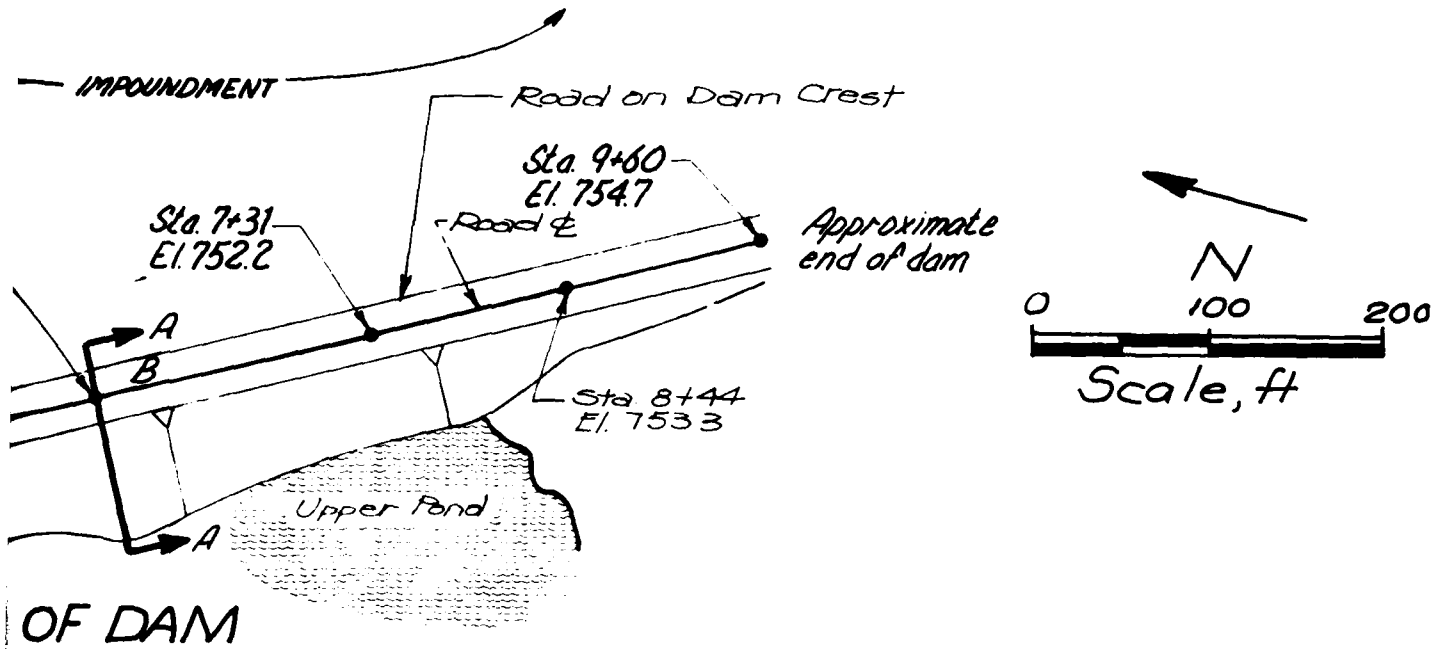
DORLAC LAKE DAM	
MO 30731	Fig. 2



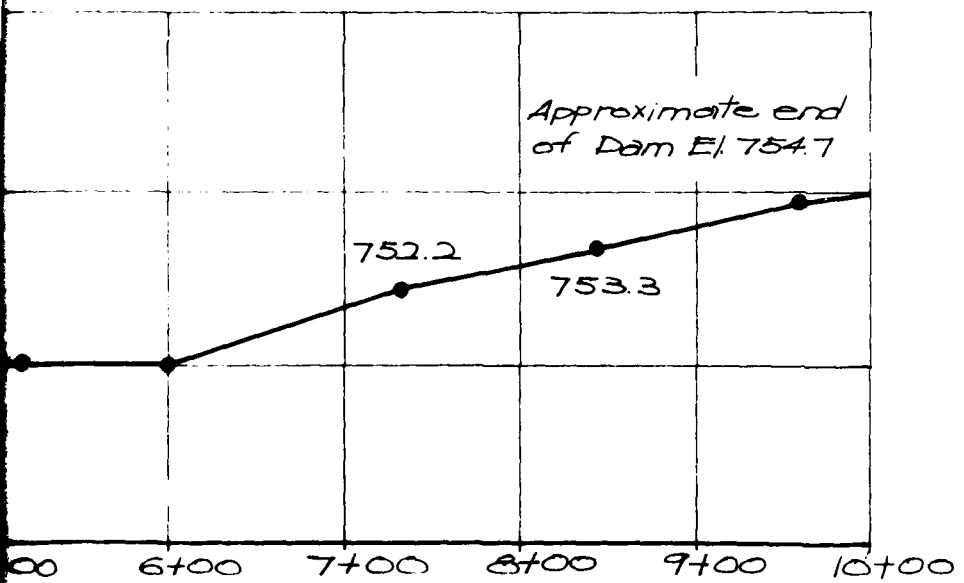
PLAN OF DAM



DAM CREST PROFILE



OF DAM

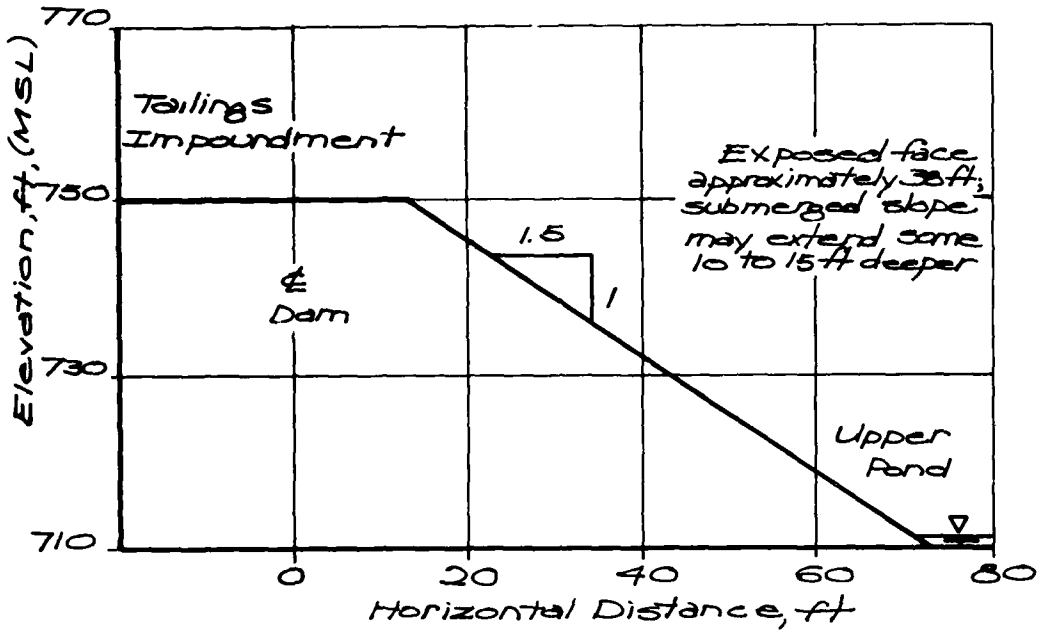


ce, ft.
line)

ROFILE

PLAN OF DAM AND PROFILE OF DAM AND SPILLWAY	
DORLAC LAKE DAM	
MO 30731	Fig. 3-A

12



SECTION A-A

Maximum Section

CROSS SECTION OF DAM	
DORLAC LAKE DAM	
MO 30731	Fig. 3-B

Legend

- Or — Roubidoux Formation
- Gasconade Dolomite
  - Gunter Sandstone Member
- Cep — Eminence Dolomite
- Potosi Dolomite
- Derby-Doerun Dolomite
- Ceb — Davis Formation
- Bonneterre Formation
  - Whetstone Creek Member
  - Sullivan Siltstone Member
- Reagan Sandstone (subsurface, western Missouri)
- Lamotte Sandstone
- Diabase (dikes and sills)
- St. Francois Mountains Intrusive Suite
- St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

DORLAC LAKE DAM

MO 30731 | Fig. 4

APPENDIX A

Photographs

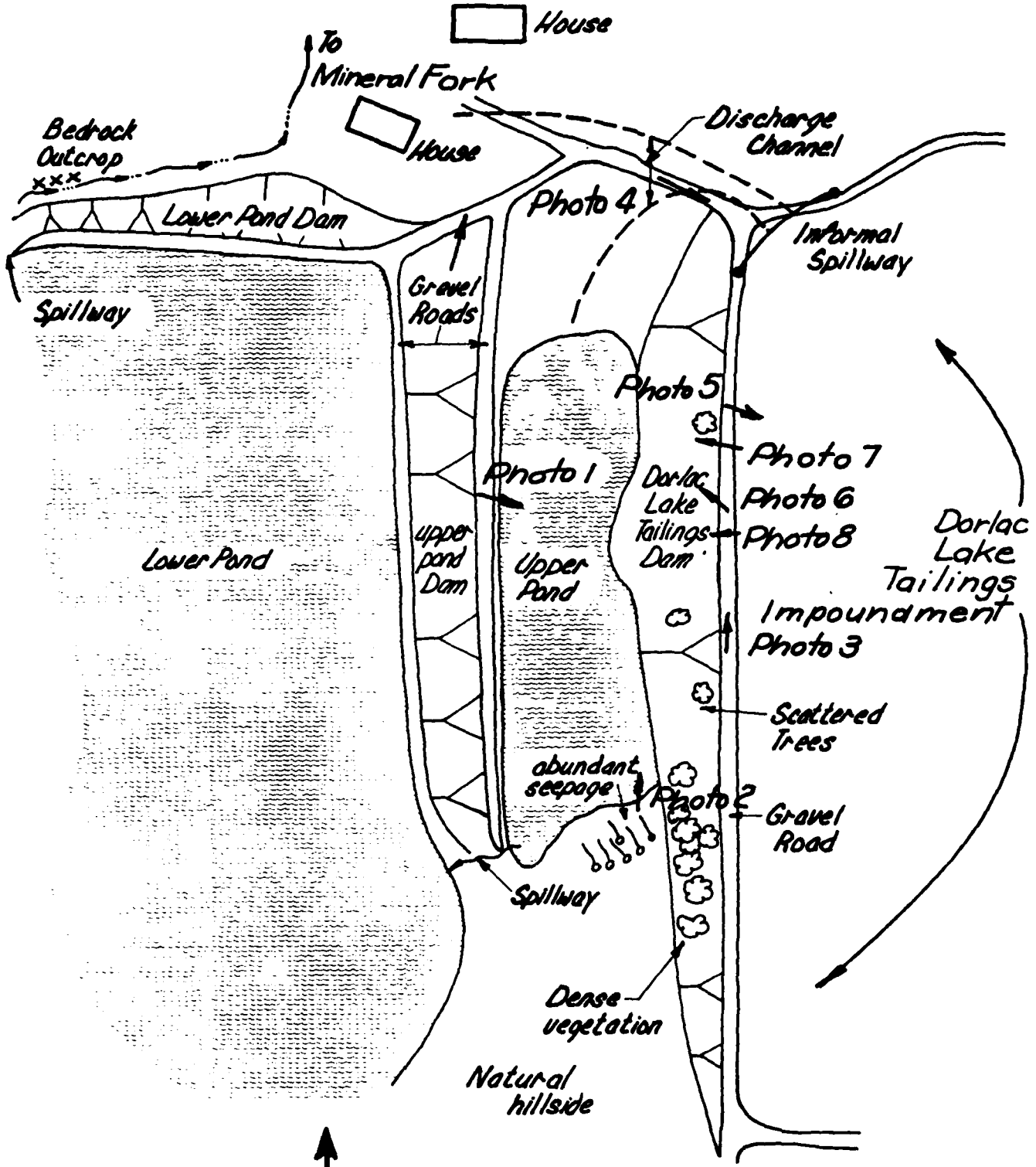


PHOTO LOCATION SKETCH	
DORLAC LAKE DAM	
MO 30731	Fig. A 1

1. Downstream face of Dorlac Lake Dam. Note pond at toe of tailings dam and vegetation growing on slope of tailings dam. Looking east, upstream.

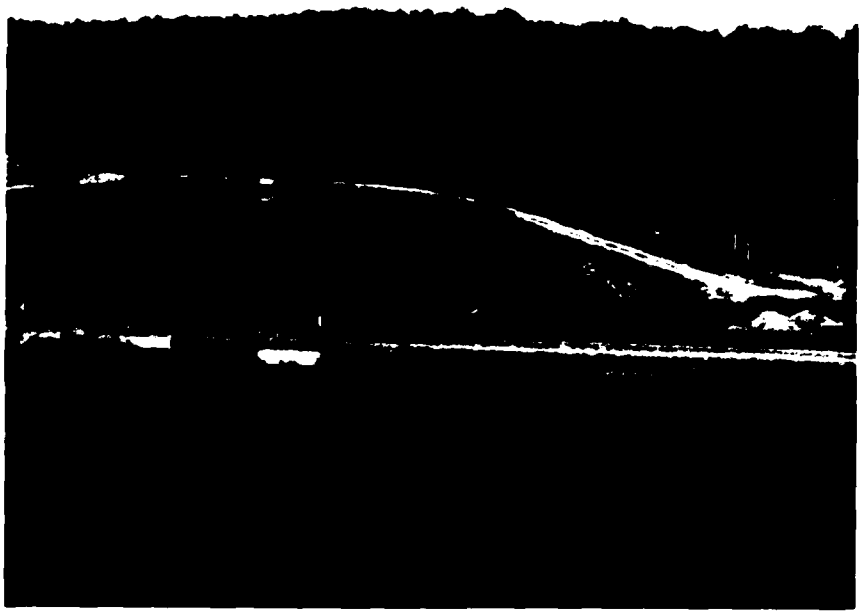
2. Toe of tailings dam. Note irregular face of dam, apparently caused by construction methods. Looking north.

3. Gravel road along crest of dam. Note level of tailings, to the right, approximately equal to dam crest elevation. Looking north.

4. Informal spillway area at right abutment. Looking east, upstream. Dam is out of picture to the right.

5. Tailings impoundment area. Vegetation on the impoundment surface has been mowed. Looking east from roadway on dam crest.

6. Dorlac residence below dam in area of possible spillway discharge. Looking northwest from dam crest.



7. Two ponds immediately downstream from Dorlac Lake Dam. Looking west from crest of dam.

8. Downstream face of tailings dam and pond covering toe of dam. Looking west from crest of dam.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8}(s+1)^{0.7}}{1900\, Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_c \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 10 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows: spillway crest elevation for both the probability events and PMF events (el. 747.4).

f. Spillway Rating Curve. The spillway rating curve was manually calculated assuming critical depth over the spillway cross-section from a cross section of the informal spillway and input to the HEC-1 program on the Y-4 and Y-5 cards.

B.2 Pertinent Data

a. Drainage area. 0.48 mi^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 10 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.77 hr

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 88
2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 75

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Tiff, Missouri 7.5 minute quadrangle map. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The spillway rating curve was developed from the cross-section data of the spillway and was entered on the Y-4 and Y-5 cards of the HEC-1 program.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 747.4 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also 747.4 ft.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 90
**********
... 1                 A1       DORLAC LAKE DAM NO. 30731
    2                 A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79CH009
    3                 A3       PROBABLE MAXIMUM FLOOD(PMF) ANALYSIS
    4                 B     249        0       10       -0       -0       -0       -0       -0       -0       -0
    5                 B1      5
    6                 J       1        2        1
    7                 J1     .5       1.
    8                 K       0     LAKE                                                    1
    9                 K1       DORLAC LAKE INFLOW HYDROGRAPH COMPUTATIONS
   10                 M       1        2     .481                          1.0
   11                 P                26.     102.     120.     130.     140.
   12                 T                                                          -1      -88                .14
   13                 M2               .77
   14                 X      -1     -.05        5
   15                 K       1      DAM                                      1
   16                 K1       FLOOD ROUTING AND OVERTOPPING ANALYSIS
   17                 Y                                          1        1
   18                 Y1      1                                                        -747.4      -1
   19                 Y4  747.4    747.8    748.1    748.3    748.6    749.0    749.4    749.7    749.9    750.3
   20                 Y4  750.8
   21                 Y5     0.     10.0     50.0    100.0    200.0    500.0    800.0   1200.0   1500.0   2000.0
   22                 Y5 3000.
   23                 S5     0.      0.       1.       2.     530.
   24                 SE  720.0    740.     747.4    750.0    760.0
   25                 S   747.4
   26                 SD  750.0      2.6      1.5
   27                 SL     0.    150.0    180.0    195.0    210.0    230.0    305.0    400.0    445.0
   28                 SV  750.0    750.2    750.4    750.9    751.4    752.1    752.4    753.4    753.5
   29                 K      99
```

Input Data
Various PMF Events
Dorlac Lake Dam
MO 30731

B4

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION  JULY 1978
 LAST MODIFICATION  01 APR 80
**********

 RUN  DATE= 19 DEC 80
      TIME= 06.54.15
```

DORLAC LAKE DAM NO. 30731
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79CH009
PROBABLE MAXIMUM FLOOD(PMF) ANALYSIS

JOB SPECIFICATION

NQ	NMR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
299	0	10	-0	-0	-0	-0	-0	-0	-0

JOPER	NWT	LROPT	TRACE
5	-0	-0	-0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 2 LRTIO= 1

RTIOS= .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

DORLAC LAKE INFLOW HYDROGRAPH COMPUTATIONS

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LAKE	0	-0	-0	-0	-0	1	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.48	-0.	.48	1.00	-0.	-0	-0	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
-0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-88.00	-0.	.14

CURVE NO = -88.00 WETNESS = -1.00 EFFECT CN = 88.00

UNIT HYDROGRAPH DATA
TC= -0. LAG= .77

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 25 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= .77 VOL= 1.00

26.	81.	172.	248.	272.	258.	220.	165.	114.	83.
61.	45.	32.	24.	17.	12.	9.	7.	5.	4.

B5

Output Summary
Various PMF Events
Dorlac Lake Dam
MO. 30731

STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 25 END OF PERIOD ORDINATES. TC= -0. HOURS, LAG= .77 VOL= 1.00

26.	81.	172.	248.	272.	258.	220.	165.	114.	83.
61.	45.	32.	24.	17.	12.	9.	7.	5.	4.
3.	2.	1.	1.	0.					

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	.00	.00	0.	1.02	1.00	150	.03	.03	.00	29.
1.01	.20	2	.00	.00	.00	0.	1.02	1.10	151	.03	.03	.00	34.
1.01	.30	3	.00	.00	.00	0.	1.02	1.20	152	.03	.03	.00	38.
1.01	.40	4	.00	.00	.00	0.	1.02	1.30	153	.03	.03	.00	41.
1.01	.50	5	.00	.00	.00	0.	1.02	1.40	154	.03	.03	.00	43.
1.01	1.00	6	.00	.00	.00	1.	1.02	1.50	155	.03	.03	.00	44.
1.01	1.10	7	.00	.00	.00	1.	1.02	2.00	156	.03	.03	.00	45.
1.01	1.20	8	.00	.00	.00	1.	1.02	2.10	157	.03	.03	.00	46.
1.01	1.30	9	.00	.00	.00	1.	1.02	2.20	158	.03	.03	.00	47.
1.01	1.40	10	.00	.00	.00	1.	1.02	2.30	159	.03	.03	.00	47.
1.01	1.50	11	.00	.00	.00	1.	1.02	2.40	160	.03	.03	.00	48.
1.01	2.00	12	.00	.00	.00	1.	1.02	2.50	161	.03	.03	.00	48.
1.01	2.10	13	.00	.00	.00	1.	1.02	3.00	162	.03	.03	.00	48.
1.01	2.20	14	.00	.00	.00	1.	1.02	3.10	163	.03	.03	.00	48.
1.01	2.30	15	.00	.00	.00	1.	1.02	3.20	164	.03	.03	.00	48.
1.01	2.40	16	.00	.00	.00	1.	1.02	3.30	165	.03	.03	.00	49.
1.01	2.50	17	.00	.00	.00	1.	1.02	3.40	166	.03	.03	.00	49.
1.01	3.00	18	.00	.00	.00	1.	1.02	3.50	167	.03	.03	.00	49.
1.01	3.10	19	.00	.00	.00	1.	1.02	4.00	168	.03	.03	.00	49.
1.01	3.20	20	.00	.00	.00	1.	1.02	4.10	169	.03	.03	.00	49.
1.01	3.30	21	.00	.00	.00	1.	1.02	4.20	170	.03	.03	.00	49.
1.01	3.40	22	.00	.00	.00	1.	1.02	4.30	171	.03	.03	.00	49.
1.01	3.50	23	.00	.00	.00	1.	1.02	4.40	172	.03	.03	.00	49.
1.01	4.00	24	.00	.00	.00	1.	1.02	4.50	173	.03	.03	.00	49.
1.01	4.10	25	.00	.00	.00	1.	1.02	5.00	174	.03	.03	.00	49.
1.01	4.20	26	.00	.00	.00	1.	1.02	5.10	175	.03	.03	.00	49.
1.01	4.30	27	.00	.00	.00	1.	1.02	5.20	176	.03	.03	.00	49.
1.01	4.40	28	.00	.00	.00	1.	1.02	5.30	177	.03	.03	.00	49.
1.01	4.50	29	.00	.00	.00	1.	1.02	5.40	178	.03	.03	.00	50.
1.01	5.00	30	.00	.00	.00	1.	1.02	5.50	179	.03	.03	.00	50.
1.01	5.10	31	.00	.00	.00	1.	1.02	6.00	180	.03	.03	.00	50.
1.01	5.20	32	.00	.00	.00	1.	1.02	6.10	181	.13	.12	.01	52.
1.01	5.30	33	.00	.00	.00	1.	1.02	6.20	182	.13	.12	.01	60.
1.01	5.40	34	.00	.00	.00	1.	1.02	6.30	183	.13	.12	.01	76.
1.01	5.50	35	.00	.00	.00	1.	1.02	6.40	184	.13	.12	.01	100.
1.01	6.00	36	.00	.00	.00	1.	1.02	6.50	185	.13	.12	.01	126.
1.01	6.10	37	.01	.00	.01	1.	1.02	7.00	186	.13	.12	.01	150.
1.01	6.20	38	.01	.00	.01	1.	1.02	7.10	187	.13	.12	.01	171.
1.01	6.30	39	.01	.00	.01	1.	1.02	7.20	188	.13	.12	.01	187.
1.01	6.40	40	.01	.00	.01	1.	1.02	7.30	189	.13	.12	.01	199.
1.01	6.50	41	.01	.00	.01	1.	1.02	7.40	190	.13	.12	.01	207.
1.01	7.00	42	.01	.00	.01	2.	1.02	7.50	191	.13	.12	.01	213.
1.01	7.10	43	.01	.00	.01	2.	1.02	8.00	192	.13	.12	.01	218.
1.01	7.20	44	.01	.00	.01	2.	1.02	8.10	193	.13	.12	.01	222.
1.01	7.30	45	.01	.00	.01	2.	1.02	8.20	194	.13	.13	.00	224.
1.01	7.40	46	.01	.00	.01	2.	1.02	8.30	195	.13	.13	.00	227.
1.01	7.50	47	.01	.00	.01	2.	1.02	8.40	196	.13	.13	.00	228.
1.01	8.00	48	.01	.00	.01	2.	1.02	8.50	197	.13	.13	.00	229.
1.01	8.10	49	.01	.00	.01	3.	1.02	9.00	198	.13	.13	.00	231.
1.01	8.20	50	.01	.00	.01	3.	1.02	9.10	199	.13	.13	.00	231.
1.01	8.30	51	.01	.00	.01	3.	1.02	9.20	200	.13	.13	.00	232.
1.01	8.40	52	.01	.00	.01	3.	1.02	9.30	201	.13	.13	.00	233.
1.01	8.50	53	.01	.00	.01	3.	1.02	9.40	202	.13	.13	.00	233.
1.01	9.00	54	.01	.00	.01	3.	1.02	9.50	203	.13	.13	.00	234.

Output Summary
Various PMF Events
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Output Summary
Various PMF Events
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Output Summary
Various PMF Events
Dorlac Lake Dam
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS	
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2
				.50	1.00
HYDROGRAPH AT	LAKE	.48	1	1406.	2812.
		(1.25)		(39.81)	(79.62)
ROUTED TO	DAM	.48	1	1404.	2571.
		(1.25)		(39.77)	(72.81)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	747.40	747.40	750.00
STORAGE	1.	1.	2.
OUTFLOW	0.	0.	1625.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	749.84	0.	2.	1404.	0.	40.33	0.
1.00	750.52	.52	29.	2571.	2.00	40.67	0.

Output Summary
Various PMF Events
Dorlac Lake Dam
MO 30731

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS	
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2
				.55	.60
HYDROGRAPH AT	LAKE	.44	1	1540.	1657.
		(1.251		(43.791(	47.771(
ROUTED TO	DAM	.48	1	1542.	1642.
		(1.251		(43.661(	46.481(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	747.40	747.40	750.00
STORAGE	1.	1.	2.
OUTFLOW	0.	0.	1625.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.55	749.93	0.	2.	1542.	0.	40.33	0.
.60	750.01	.01	3.	1642.	.33	40.50	0.

Output Summary
Various PMF Events
Dorlac Lake Dam
MO 30731

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